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ABSTRACT

The Value-Added Beef program (VAB) has received core funding from the Saskatchewan Beef Development Fund since 1996. Its objective has been to establish an applied research and new product development capability specifically for beef. This program has provided a focused approach to value-added beef development and has supported continued viability of Saskatchewan's agri-food industry by undertaking both reactive and proactive research and development activities. This program has cooperated with / build on the strengths and expertise of the former ADF-funded Value-Added Meats Strategic Research Area (Saskatchewan Food Product Innovation Program).

Initiatives undertaken under the VAB program have been focused on various approaches for improving beef quality and consumer satisfaction. They explored the options and potential for adding value to beef products through improving beef quality and tenderness and stimulating beef product development to improve market access and ensure beef's competitive position. Over the past eight years, the Value-Added Beef Program has also provided extension assistance and technology transfer to the beef cattle and meat processing industry through numerous presentations, extension publications and workshops. In January of 2004, the Saskatchewan Beef Development Fund approved funding for an additional five years of partial support for this program. This enables us to continue to have the infrastructure in place to continue value-added beef research and to assist the industry in any expansion of beef processing activity in the province.

EXECUTIVE SUMMARY

The Value-Added Beef program (VAB) has received core funding from the Saskatchewan Beef Development Fund since 1996. The objectives of the program were as follows: to establish an applied research and new product development capability specifically for beef, to provide a focused approach to value-added beef development, to assist the industry in understanding the needs of consumers and to provide industry support to assist in the development of value-added beef products and in turn increase viable overall growth of this industry in Saskatchewan by undertaking both reactive and proactive research and development activities.

Initiatives undertaken under the VAB program have been focused on various approaches for improving beef quality and consumer satisfaction. They explored the options and potential for adding value to beef products through improving beef quality and tenderness and stimulating beef product development to improve market access and beef's competitive position.

Research activities have included the following: developing processing procedures for restructured meats, improving utilization of beef bones, assessing demand for value added beef products, supplemented by a consumer study (note: this was done in collaboration with the Department of Agricultural Economics at the University of Saskatchewan), meat quality evaluations to support genetics research in the Department of Animal and Poultry Science, evaluating functionality of selected beef cuts for further processing, investigating effects of mechanical treatments and moisture enhancement on the processing characteristics and tenderness of beef from the round, monitoring the effects of cooking cycle on the tenderness of bison and beef roasts; finding the effects of vacuum and modified atmosphere packaging on the colour and shelf-life of bison and beef steaks; and developing postmortem intervention strategies to enhance tenderness of underutilized beef cuts in order to ensure a consistently tender product from underutilized meat cuts (note: this project is currently underway in collaboration with Agriculture and Agri-Food Canada Research Centre, Lacombe, AB).

Most consumers judge quality and overall acceptability of beef products based on tenderness, which has been identified as the single most important palatability factor affecting consumer satisfaction of beef. Therefore the main emphasis of this project has been to improve the processing characteristics and thus increase utilization of lesser value cuts and thereby increasing the overall value of the carcass. The findings from various studies conducted under this project suggest that marination by injection has a great deal of potential in improving the palatability of lesser value cuts of meat. Mechanical treatment of meat tissue including blade tenderization or tumbling can greatly enhance tenderness and can be successfully used by beef processors to ensure tenderness of tougher cuts such as round muscles. In addition the results suggest that moisture enhancement of lesser value cuts of beef and bison SM muscles followed by the appropriate cooking regime offers a new means of ensuring consistently tender products.

Structured lean roast beef products represent a potential growth area for the beef industry due to lower cost, low-fat content and convenience. It was found that the utilization of restructured technology could lead to an increase in the utilization of lower price cuts as well as increasing the value-added beef products available at retail. Restructured beef steaks can be successfully manufactured with either sodium alginates or Fibrimex™. We have furthered our understanding

of how to optimize functionality of the proteins in red meat systems. For example, tumbling can be important to facilitate the restructuring of meat pieces into a value-added final product. However, the quantity and timing of brine/water addition is critical in ensuring good water binding and textural characteristics of cooked beef rolls. Late addition of brine/water during tumbling is detrimental and did not permit the incorporation of the water/brine into the muscle cells so that they were retained both in raw and cooked state.

The preservation of appearance and quality is essential during the distribution and merchandising of perishable products like meat. The only criterion consumers have at the point of purchase when selecting meat cuts is visual appearance. During retail display, optimum storage temperature and appropriate packaging is necessary to prevent product shrinkage and delay the onset of product deterioration. The data acquired also suggested that marination and moisture enhancement of beef did not decrease the storage life of fresh beef.

A major market development project undertaken by the program was in collaboration with the Department of Agricultural Economics at the University of Saskatchewan. This project analyzed the current and potential status of sources of beef used for manufacturing and grinding in Saskatchewan in a Canadian context. The project was aimed to better understand consumer preferences of selected processed products and to examine the domestic marketing chain for beef products.

Findings from these studies have been communicated to beef producers and processors through presentations and fact sheets/newsletters, and have also been presented at scientific meetings as well as being published in industry magazines and international peer-reviewed journals (*e.g.*, Meat Science, Journal of Muscle Foods). Sincere efforts were made to publicize the program and to reach as many producer/processor groups, industry and government personnel as possible.

The Value-Added Beef Program has been fortunate to find skilled personnel to meet its mandate. Dr. Jane Boles was the professional research associate and program coordinator with the program from 1996 to 1999. She carried out a number of research and development activities and was instrumental in obtaining significant additional funding for value-added beef research by leveraging funding we received from BDF. In January of 2001, Dr. Zeb Pietrasik joined the VAB program and since then he has added his meat processing expertise to various research activities for the program. Mr. Paul Rogers joined the Saskatchewan Food Product Innovation Program (SFPIP) as a meat processing specialist in 2001. He is partially supported from this program.

Another key area of the program was related to various forms of extension including consulting, troubleshooting, technology transfer and product and process development. This program has provided advice and collaboration with various other departments and groups, including the Department of Animal and Poultry Sciences, Beef Development Centre, Department of Agricultural Economics, Saskatchewan Agriculture, Food and Rural Revitalization and the Canadian Beef Information Centre (BIC). Indeed, a question posed by the BIC lead to the development of a popular meat colour extension publication from the program.

We are grateful for the collaboration and contribution of SFPIP staff (partially funded by this initiative) who carried out much of the ongoing beef product and process development. Work often extended beyond the bench-top or pilot scale, with staff providing assistance with scale-up of these new products at the plant level or in cooperation with the Saskatchewan Food Industry Development Centre. Several new and novel beef products have now been commercialized.

During the past eight years, the Value-Added Beef program was in attendance at many trade shows, meetings and conferences to gain access to new technologies and to make contacts with potential clients in the beef industry sector. These included Canadian Cattleman's Association Annual Conventions, Saskatchewan Beef Symposium, Canadian Meat Science Association / Canadian Meat Council's Annual Technology Symposiums, Annual Conventions of Saskatchewan Meat Processors' Association, Western Beef Development Centre Termuende Annual Field Days, Grand Opening of the Saskatchewan Food Industry Development Centre, International Animal Agriculture and Food Science Conference, Reciprocal Meat Conference and International Congress of Meat Science and Technology. Important new contacts were made during these meetings.

In January of 2004, the Saskatchewan Beef Development Fund approved funding for an additional five years of support for this program. Thus we will continue to have the infrastructure in place to continue our value-added beef research and to assist the industry in any expansion of beef processing activity in the province.

INTRODUCTION

Saskatchewan is the second-largest beef-producing province in Canada. Currently only a small proportion of beef cuts from a beef carcass is used for further processing. Less than 40% of beef produced is further processed while it has been reported that over 70% of pork and chicken is further processed. Historically, the beef industry has focused primarily on the production and consumption of fresh, high valued meat products such as steaks and roasts. These products are sold to consumers as fresh meat that requires little additional processing other than cutting into appropriate meat cuts for consumers. These beef cuts make up less than 40 per cent of the beef carcass, with the remainder of the carcass being comprised of cuts that are usually ground into lower valued products.

Beef chuck and round have been described as the most under-utilized wholesale cuts from the beef carcass. These undervalued primals, which represent more than 50 per cent of the carcass, are less palatable in the fresh, unprocessed form and are usually marketed as low priced roasts or ground into lower valued products. Since most consumers judge quality and overall acceptability of beef products based on tenderness, the utilization of meat from the beef round and chuck has always been limited by the toughness of the muscles. In addition, convenience is of growing importance to the consumer.

The ability to produce and sell value-added beef provides the beef industry access to a large and growing marketing opportunity. There is a need for technologies that would permit Saskatchewan meat processors to add value to their products and to compete in domestic and national markets. It was felt that increasing our potential to process beef into value-added retail-ready products for local and national consumption, niche markets and export to distant markets was of strategic importance to the province. It was also felt that improved consumer satisfaction with new value added products would increase demand for meat production and provide an increased stability to the entire meat industry. There is a crucial need to maximize beef quality and production efficiency in all aspects of the meat industry in order to maintain and stimulate product utilization.

Thus in 1996 with project funding from the Saskatchewan Beef Development Fund, the Value-Added Beef program was established. The program was designed with objectives to establish an applied research and new product development capability specifically for beef, provide a focused approach to value-added beef development, to assist the industry in understanding the needs of consumers and to provide research support to assist in the development of value added beef products and in turn increase viable overall growth of this industry in Saskatchewan.

Over the past eight years, personnel involved with the Value-Added Beef (VAB) program have attempted to address some of these issues. Some of the key activities that were carried out by the VAB program are described in detail in the following sections.

ACTIVITY 1: Processing Procedures for Restructured Meats (1995-1998)

Background

One of the major obstacles to utilizing beef from the round and chuck is the variability of the muscles, especially in tenderness. Most of the meat from the chuck is used for grinding meat. However, hamburgers are seen as a lower margin product. Changes in the way restructured meat is manufactured could result in products that the consumer would be willing to pay more money for. The manufacture of value-added beef products that give consistent eating experiences will increase the market for these products. Beef offerings, at the retail counter and for the HRI trade, has not changed much in the past twenty years. Efforts to increase the value-added beef offerings in the market could help stop the downward trend in beef consumption. If the offerings of versatile, convenient beef in the store do not increase, beef's market share may continue to be eroded.

Cold-set binders such as alginates and Fibrimex™ as well as salt and phosphates have been investigated in beef products. Cold-set binders are products that can be used to hold fresh - unfrozen meat together to give an appearance similar to whole muscle products. However, the technology has not been utilized much for products aside from boneless hams and chopped and formed roast beef (Arby's and Rax type products). One of the main reasons this technology is under utilized is the lack of general information about the practical aspects of how the binders work and how processing methods affect the finished product.

Objectives

The objectives of this activity were:

1. to determine how different methods of particle size reduction (grinding, slicing or flaking) affect the texture and particle bind of restructured meat products.
2. to evaluate the effect of different muscle location / cut on the texture and particle bind of restructured meat products.

Experiment 1.1. Establish how size reduction method and size affect the texture of different meat binding systems

Procedures

The effect of particle size, method of particle size reduction (grinding, flaking, slicing) and alginate or Fibrimex™ binding systems on processing properties of restructured beef was investigated. The size of inside round muscles was reduced with a meat slicer, grinder or flaker (Comitrol) through machine openings that were 2, 4 and 8 mm in size. Bind of meat pieces in raw and cooked beef steakettes were measured. Sensory evaluation to determine the effect of method of size reduction on texture of beef steakettes was done only on steakettes manufactured with alginate.

Results

Beef steakettes manufactured with the alginate binding system had significantly ($P<0.05$) higher raw bind values than did the beef steakettes manufactured with Fibrimex. Slicing meat for the manufacture of restructured beef steakettes resulted in a higher raw bind than did either grinding or flaking the meat. Significant ($P<0.05$) interactions were observed for the bind of cooked steakettes between binder and method of size reduction and binder and opening size. When alginates were used to make restructured steakettes the bind of the cooked product was less ($P<0.05$) when meat was sliced than when it was ground or flaked. However, when Fibrimex was used, bind was stronger when sliced meat was used. The alginate system resulted in higher binds for cooked product when particle size was smaller but with the Fibrimex system bind was higher when particles sizes were larger. A consumer panel on alginate restructured steakettes showed no preference for the texture produced by the different methods of particle size reduction.

Conclusions

- Restructured beef steaks can be manufactured with either sodium alginates or Fibrimex™.
- The method of size reduction used to get similar results in the finished product for each type of binder system is slightly different. If using Fibrimex™, larger particle pieces should be used so that the exposed surface area is smaller and there is more of the solution to coat individual pieces. Alginates, however, have better binding properties with increasing surface area.
- Sensory panelists showed no preference for the texture produced by the different methods of particle size reduction. This suggests that texture is not as important as juiciness to the consumer for this type of product. A trend, however, was seen for the preference of restructured steakettes manufactured with ground meat as opposed to flaked meat.

Experiment 1.2. Establish how muscle location affects texture of restructured meat products.

Procedures

Inside rounds, chuck tenders, chuck clods and tri-tips were obtained from a commercial processing plant ground through 8 mm plate and used to manufacture restructured logs. The effect of meat cut used and alginate or Fibrimex™ binding systems on processing properties of restructured beef was investigated. Bind of meat pieces in raw and cooked beef steakettes were measured. Sensory evaluation of the effect of cut on the acceptability of restructured steakettes was done for both alginate and Fibrimex product.

Results

The binder used to manufacture restructured steakettes significantly affected the bind of raw and cooked product as well as the cook yield and dimensional changes of the steakettes. Steakettes

manufactured with alginate had significantly ($P<0.05$) higher bind of particle pieces in the raw state but Fibrimex had greater bind between meat pieces when the steakettes were cooked. Steakettes made with alginate had significantly higher ($P<0.05$) cook yields than did steakettes made with Fibrimex. Steakettes made with Fibrimex had significantly ($P<0.05$) greater dimensional changes during cooking than did steakettes made with alginates. Meat cut used to manufacture restructured steakettes had no effect on any of the processing parameters measured.

Steakettes made with alginate were significantly darker than steakettes made with Fibrimex. Cut used to manufacture steakettes also affected the lightness. Steakettes made from chuck clod were significantly ($P<0.05$) lighter (higher Hunter L^*) than steakettes made from chuck tender or insides but were not different from steakettes made from sirloin tips. Steakettes made with Fibrimex were generally redder (higher Hunter a^* values) and yellower (higher Hunter b* values) than those made with alginate. Redness of steakettes made from chuck clod, chuck tender and inside round were similar for both binders but when sirloin tip was used, steakettes made with Fibrimex were significantly ($P<0.05$) redder (higher Hunter a^* values) than those made with alginate. Steakettes made from chuck clod, sirloin tips and insides with alginates had similar Hunter b* values to steakettes made from chuck clod with Fibrimex.

A significant interaction occurred between binder and days of retail storage for Hunter a* and b* values. Redness and yellowness decreased with retail storage. However, the change in redness (Hunter a* values) and yellowness (Hunter b* values) over time was similar for both binders. Again, steakettes made with Fibrimex were more red and yellow at all days than were steakettes made with alginate. When alginate was used to manufacture beef steakettes no difference in the acceptability of flavor, juiciness, texture and overall was determined. However, when Fibrimex was used to manufacture the steakettes a significant difference in the acceptability of juiciness, texture and overall was seen. Steakettes manufactured from clod was scored more juicy than any of the other cuts used. The texture was scored higher for steakettes made with clods and tips than steakettes made with tender and insides.

Conclusions

- A steakette with similar bind can be manufactured using any of the four cuts we investigated, clod, tender, tips or insides with either alginate or Fibrimex.
- Steakettes made with Fibrimex were redder than steakettes made with alginate but the decline of colour on storage was not different between the two binders.
- Acceptable restructured products can be manufactured with any of the cuts investigated when alginate is used. When Fibrimex is used, products made with clod or tip are more acceptable than tender or insides. This suggests that acceptable steakettes can be made with lower priced chuck clod when compared to steakettes made from the more expensive sirloin.

Funding

The Saskatchewan Agriculture Development Fund provided additional funds towards this activity. See Appendix 5.

ACTIVITY 2: Utilization of Beef Bones (1996-1998)

Background

Bones from meat processing are mostly used to manufacture meat and bone meal. There is some meat still attached to the bones that could be used for further processing if a method could be developed to extract the proteins and make an economical ingredient. The efficiency of extraction as well as the functionality of the extracted protein as an ingredient in processed meat products need to be tested. Currently, the main method of protein recovery from bones, is using mechanical deboners. These machines recover a portion of the protein but some still remains on the bone. Some researchers have used whole bones or the residue from mechanical deboners to recover meat proteins with varying levels of success. Fonkewe and Singh (1994) used salt solutions at different pH values, extraction temperatures and solvent ratios to extract protein from mechanically deboned turkey residue. They found that the best extraction conditions was 1% sodium chloride, pH 10 at a 5:1 ratio, extracted for 16 min at 37°C. These conditions, however, extracted only 5% of the total protein available. An improvement in extraction efficiency is necessary to make the procedure economical. Also, conditions used for extraction should not be detrimental to the meat proteins thereby making the extract a functional ingredient in processed meat products.

In addition to increased utilization of beef bones, new product development will create opportunities for diversification. New beef products, designed specifically for using beef bones could have a significant economic impact on Saskatchewan beef producers by increasing the value of what is now a by-product of little value.

Objectives

The objectives of this activity were:

1. to investigate processing methods for extracting functional proteins from bones.
2. to determine the functionality of the extracted proteins in processed meat products.

Procedures

Protein extraction

Four solutions (4% sodium chloride (control), 4% sodium chloride with either 0.3% sodium tripolyphosphate [STP], 0.3% tetrasodium pyrophosphate [TSP] or 0.05M sodium hydroxide [NaOH]) were used to extract proteins beef bone residue and three solution to bone ratios were investigated (1:1, 1:4 or 1:10). In addition, three bone types (vertebra, rib and femur) and two methods of protein recovery from the extraction slurries (dialysis against 0.03M potassium phosphate buffer [pH 5.3] and acid precipitation) were evaluated.

Test Products

Two protein extraction solutions, 4% sodium chloride with 0.3% trisodium polyphosphate (STP) and 4% sodium chloride with 0.05M sodium hydroxide, were chosen for study in sausage

products. Vertebra bones were obtained from a cold-boning beef slaughter plant. Bones were cut into 4 cm slices and extracted with 4 volumes of extraction solution in a tumbler (4°C).

The treatments for manufacture of the finely comminuted sausages were as follows;

- protein from 4% sodium chloride with 0.3% STP extraction recovered by acid precipitation
- protein from 4% sodium chloride with 0.3% STP extraction recovered by dialysis
- protein recovered from 4% sodium chloride with 0.05M sodium hydroxide extraction by acid precipitation
- protein from 4% sodium chloride with 0.05M sodium hydroxide extraction by dialysis
- soy isolate (Protein Technology International, St. Louis, MO)
- dried plasma (UFL Food Ingredients, Calgary, AB)
- whey protein (American Meat Protein Corporation, Ames, IA)
- control (no added protein, 12% meat protein)

A formulation typical of a finely comminuted sausage product was prepared from ground inside and outside round, beef fat, ice and salt. The amount of each ingredient was adjusted to produce batters with approximately 12% protein, 23.2% fat, 62.2% water, 2% added salt and 0.6% ash. Protein based additives were added to the batter to give 2% added protein. Meat protein was adjusted so that all batters had a total protein content of 12%. Cook yield and textural properties of sausages (shear stress and strain at failure) were measured.

Results

Protein Extraction

Analysis of the bones prior to extraction showed that vertebra (19.8%) had more protein than did ribs (17.8%) followed by leg bones (15.9%). More protein was recovered from the vertebra than the rib bones and the least was extracted from the leg bones. Sodium tripolyphosphate and sodium hydroxide were the most effective extraction solutions when proteins were extracted from vertebrae but when rib bones were used sodium hydroxide and tetrasodium polyphosphate extracted more protein. When proteins were extracted from leg bones there was poor recovery with all extraction solutions with sodium hydroxide being the most effective.

The ratio of extraction to bone was very important to the efficiency of extraction. For vertebra and rib bones, a 10 to 1 ratio resulted in a higher percentage of proteins recovered than did 4 to 1 or 1 to 1 with all extraction solutions.

Protein recovery

Significant interactions were seen between bone and extract used, extract used and ratio of extract to bone material, and bone and extract used and ratio of extract to bone for proteins recovered from bone material using either acid precipitation or dialysis. In general, of the two methods of protein recovery used, the recovery was best when sodium hydroxide or tetrasodium pyrophosphate was used to extract the proteins. When acid precipitation was used to recover proteins from extraction solutions, the best recovery occurred when the concentration of proteins in the extract was highest; 1 to 1 or sometimes 4 to 1 ratio of solution to bone or vertebra bones were extracted. Dialysis recovery of proteins, however, worked best when the concentration of

the proteins were the lowest in the extraction solution; 10 to 1 solution to bone ratio or leg bones were used. Furthermore, the dialysis method of recovering proteins had a more consistent recovery of proteins across the different bones and solutions than the acid method of recovering proteins.

Proteins as a sausage ingredient

Four test myofibrillar protein extracts were tested against typical commercial protein additives in finely comminuted meat batters. The control batter contained 12% meat protein while the test batches contained 10% meat protein and 2% of the test proteins. The texture of these batters were evaluated using a gelometer. Stress of the protein gels manufactured with the bone extracts were similar to the stress of protein gels made with commercial proteins. The stress of protein gels made with sodium hydroxide-extracted, dialysis-precipitated proteins was significantly lower than the stress of protein gel made with sodium hydroxide-extracted, acid precipitated proteins. Strain of protein gels were also similar except for the meat control which had a lower strain than the protein gels made with added proteins. Stress modulus (G) was similar for all protein gels except the protein gel made with whey protein. The slope of the line at failure was also similar for the all of the protein gels with the control having the flattest slope and soy plasma protein had the steepest slope.

Cook yields were higher for protein gels using dialysis-precipitated bone proteins than acid-precipitated bone proteins, but no difference was seen between sodium hydroxide or sodium tripolyphosphate extraction. The cook yields of protein gels made with dialysis-precipitated proteins were similar to cook yields of protein gels made with soy protein, plasma protein and whey protein. These were also equal or better than controls. Further evaluation by a sensory panel would be desirable.

Conclusions

- Different solutions can be used to effectively extract proteins from beef bones.
- Bone type can greatly affect the efficiency of extraction and recovery of proteins. In this experiment, vertebra bones were the best bones to use to recover proteins for use as ingredients. A solution to bone ratio of 10 to 1 recovered the most proteins from bones for both vertebra and rib bones.
- Dialysis is the best method to use to recover proteins if the protein concentration in the extraction solution is low. Acid precipitation, however, works best if the concentration of proteins in the extraction solution is high.
- Proteins extracted from beef bones can be used to manufacture finely comminuted sausage products with similar texture to commercially available proteins.
- A detailed cost analysis is needed before this technology could be implemented.

Funding

Some funding for these experiments was obtained from the Saskatchewan Agriculture Development Fund (See Appendix 5). The bones were kindly donated by Western Canadian Beef Packers, Ltd, Moose Jaw.

ACTIVITY 3: Mapping Carcass Traits By Microsatellite Typing In Beef Reference Families (1996-1997)

Background

Tenderness has been identified as one of the challenges to beef consistency. The opportunity to determine the genetic impact on tenderness could lead to a more consistent product on the market. Therefore the mapping of characteristics to establish the markers for tenderness of the meat is important to the fresh meat trade.

This activity used meat from a larger study that was conducted by Dr. Sheila Schmutz and Dr. Fiona Buchanan of the Department of Animal and Poultry Science in cooperation with the Agriculture Canada Meat Research Station, Lacombe, AB. They mapped the genes of animals with very specific backgrounds to determine if they can find a genetic marker for tenderness. Other researchers from the University of Alberta, University of Lethbridge and the Lacombe Research Centre measured various traits of tenderness to help map tenderness traits. The objective of this activity was to determine the tenderness of steaks from three different parts of the carcass and make this information available to Drs. Schmutz and Buchanan for their use for genetic mapping.

Procedures

Meat was obtained from the parental animals (6 bulls and 16 heifers). Meat from the round and the chuck was removed 24 hr postmortem, vacuum packaged and frozen for transport from the Lacombe Research Centre to the University of Saskatchewan. Product was tested for water-holding capacity, cooking loss of sausage type batters, extractability of salt-soluble proteins, and stress and strain of heat set gels made from the meat obtained. Tenderness of round muscle was tested as well as one steak from the loin.

Meat was obtained from the progeny from the round (*biceps femoris* muscle and *semimembranosus* muscle) and loin for tenderness measurements. Steaks were cooked to an internal temperature of 75°C and square cores cut for Warner-Bratzler shear analysis.

Results

Shear analysis of steaks from the parental animals and progeny were completed. This information was forwarded to Drs. Sheila Schmutz and Fiona Buchanan to contribute to their analysis of the genetic data.

ACTIVITY 4: Demand for Value Added Beef Products (1997-1999)

This activity was developed as a cooperative project with Dr. Julia Taylor of the Department of Agricultural Economics at the University of Saskatchewan.

Background

North American beef research has focused primarily on the production and consumption of fresh, high valued steaks and roasts. These beef cuts make up less than 40 per cent of the beef carcass, with the remainder of the carcass being comprised of cuts that are usually ground into lower valued products.

For the beef industry to take advantage of the entire carcass, research devoted to the lower valued cuts of the beef carcass must be completed. If the value of these cuts can be increased, even marginally, all members of the beef chain stand to benefit. Increased per capita consumption through greater consumer acceptance of beef products, and value-added processing of low valued beef cuts, while distinct issues, are nonetheless closely related as the beef industry attempts to regain lost market share.

To properly serve a market, firms at all segments of the beef production chain must know what their consumers demand from their products. To this end, this research investigated the demands for manufacturing and grinding beef (which make up the largest portion of the beef carcass) at three levels. The processors of these beef cuts have specific requirements of the meat that they purchase from packers. These processors, in turn, have very little public information on consumer demands for their products. Researching the consumer demands facing beef packers and processors should increase the efficiency of existing markets and facilitate the development of new ones. The wholesale sector is the link between supply and demand in many cases. Procurement efficiencies can greatly increase the competitiveness at all points in the marketing chain.

While some studies have been done on the manufacturing and grinding beef sectors, the main focus has been on trade and quality issues (See, for example, The Report of the Beef Industry Trade and Development Committee, Dec. 1995, The (US.) National Beef Quality Audit, 1992). Most consumer demand studies have focused on the fresh beef trade, yet over 60 per cent of a beef carcass yields meat that is not suitable for traditional fresh beef consumption in the form of steaks and roasts. Manufacturing and grinding beef must be further processed and value added into products such as sausages, pastrami, or ground beef patties. As a result, these meats have the largest value added potential in terms of beef. The value added segment of the beef industry, with respect to these cuts, has had little consumer information collected in terms of what final consumers want.

In order to expand further processing of beef in Saskatchewan, there must be some understanding of the structure of this sector in a national context, and of the needs of this sector to be competitive.

Objectives

The objectives of this study were:

1. To assess the current and potential status of further processing of manufacturing and grinding beef in Saskatchewan in a Canadian context.
2. To investigate the consumer preferences of selected processed products.
3. To examine the domestic marketing chain for beef products.

Procedures

To achieve these objectives, written surveys were sent to both processors and wholesalers to determine their needs for beef. Consumer focus groups were conducted to evaluate the current attitudes about processed beef products.

Conclusions

- Surveys of Canadian meat processors indicate that there is a potential market for lean North American beef. The current lean North American product doesn't meet processor requirements. Alternative production methods such as grass-fed steers and heifers or virgin bulls may be an option. This type of product would have to be marketed outside of the current beef grading system to be profitable.

- There appears to be a general lack of communication throughout the beef supply chain. Processors using beef from Non-NAFTA countries perceive the product as being more consistent over time, more affordable, and providing specifications that are unavailable from North American suppliers. Price is more important to processors than consistency of the raw meat purchased. Processors see food safety as the most important consumer issue for the next five years.

- Wholesaler results were similar to processors except in the following areas. Product consistency over time (ie meeting specifications) and reliability of delivery is more important to wholesalers than processors due to their use of just-in-time delivery. Wholesalers feel ease of preparation will be the most important characteristic to consumers in the next five years - along with consistency of product.

- While consumer perceptions were wide ranging, some consistent themes were evident. Canadian beef has a positive image and thus should be promoted when used in processed meats. Sausage processors need to build more consumer confidence in the use of quality ingredients. Standardization of labels, including nutrition, code dates, flavour variety and percentage fat clearly displayed will help consumers zero in on attributes that are important to them. Consumers want to be able to visually inspect the product and thus packaging graphics/labels should allow for a clear viewing window of the product. Package appearance had more recall than brand name. Product experience is what they associated most with the image of products. Promotions and advertising were seen as lacking for beef products compared to pork and chicken. Product sampling and recipe suggestions would encourage participants to try more beef products.

- The meat industry and consumer attitudes are constantly changing. This information must be evaluated in this context. By completing this research the groundwork for further research into the potential of further processed beef products in Saskatchewan has been laid.

Funding

The Saskatchewan Agriculture Development Fund and the Saskatchewan Beef Development Fund supplied additional funding for this activity (Appendix 5).

ACTIVITY 5: Functionality Of Selected Beef Cuts For Further Processing – Mini Roast Beef and Stir Fry (1997-2000)

Background

The look of the fresh meat case in the grocery store is changing. Pot roasts have given way to stir-fry and sweet and sour pre-cut meats and marinated kebabs. It is predicted that the raw materials for meals that are currently being sold in the supermarkets will be replaced by, what is being called by the industry, home meal replacements or meal solutions. These items can either be complete meals that are only reheated or they can be the raw materials for the complete meal all packaged together so the consumer can feel that they contributed to making the meal. These items require a much narrower specification for the meat ingoing and more information is needed than simply the fat content. Consistency is very important. A large proportion of the processors getting into the home meal replacement market are also not the traditional meat processors. They are more likely to have other types of food products as their main or original line of products. This makes it extremely important to be able to describe the beef product that is being supplied. Without good specifications these processors may not wish to use beef in their products.

Currently little beef is used for further processing. The major reason sited for not using beef for further processing is the cost and variability of the raw material. Information about the processing capability of individual cuts of meat could help reduce the variability by allowing processors to sort meat differently than what has traditionally been done. Also, different processing techniques could be used to manufacture acceptable products with lower priced raw materials. Use of lower priced raw materials would increase the amount of beef used for further processing.

Objectives

The objectives of this activity were:

1. to determine the effect of different cuts on roast beef and stir-fry strips
2. to evaluate how selected processing techniques affect the texture of roast beef and stir-fry strips

Experiment 5.1 Effect of different muscles on the processing characteristics of roast beef.

Procedures

Seven cuts were obtained from young (<2 years) Canada Grade A carcasses for evaluation. The cuts were ones that are commercially produced. This allows for application of the information more rapidly with no changes in current cutting techniques needed. These cuts were: inside round (trimmed to *semimembranosus* muscle only), outside round (*biceps femoris*

muscle), eye of round (*semitendinosus* muscle), sirloin tip (*vastus lateralis*, *rectus femoris*, *vastus medialis* muscles) chuck clod (trimmed to *infraspinatus* muscle only) chuck roll (*seratus ventralis*, *complexus*, *longissimus thoracis* muscles) and brisket (*pectoralis profundus* muscle). Muscles were obtained from the same animals so comparisons were made between muscles within a carcass. For this experiment multiple carcasses (8) were evaluated to increase the accuracy of the information. Right and left side designation was maintained to allow for the treatments to be blocked within the experiment.

Small pre-cooked retail type roast beef were manufactured from each of the different muscles. Muscles were cut into 750 g ± 50 g pieces and pumped 0%, 10%, 25% and 50% with a standard brine. The injector was set to a specific setting and all cuts were injected at the same level. The cuts were vacuum tumbled constantly for 30 min, then packaged in cook bags and steam cooked to an internal temperature of 73°C. The cook schedule used was a step up procedure starting at 50°C for 1 hr, then increased to 60°C for 1 hr, followed by 70°C for 1 hr, then cooked at 75°C until final temperature of 73°C was reached. Yield and texture of each piece was determined. Texture was tested using a Warner-Bratzler shear and Kramer shear devices attached to a Food Texturometer. A total of 224 samples were evaluated for texture, yield, moisture and protein of cooked roasts and pH of cooked roasts.

Conclusions

- Cook yield for small retail type roasts were highest when using chuck roll, inside or outside round. Roast beef made from brisket or eye of round were the least tender.
- Roasts injected 25% over original weight had higher cook yields than roasts injected 10 or 50%.
- Increasing injection level resulted in increased expressible moisture.
- Cook yield increased after injection with chuck roll having the highest cook yield of all meat cuts evaluated after injection.
- Injection increased the tenderness of all meat cuts evaluated and made roasts from the chuck roll, clod or knuckle the most tender. It also reduced tenderness variability.

Recommendations

- When small (>1 kg) roasts are made, cook yields are less than when larger pieces are used. This indicates that it may be necessary to incorporate starch or soy protein into brines used for these types of roasts to increase yields.
- The use of clod and chuck roll result in increased yields and with injection can be used successfully to manufacture pot roast type retail ready roasts.
- More information is needed about the connection between increased injection levels and the increase in expressible moisture. This information could be useful in the manufacture of deli roast beef to allow the prediction of purge in the package.

Experiment 5.2. Effect of tumbling regime on the processing characteristics of roast beef.

Procedures

The second portion of this experiment looked at the effect of tumbling on the cook yields of precooked roast beef. Tumbling prior to injection and different tumbling regimes was investigated to improve the processing characteristics of beef mini roasts. No tumbling was compared to continuous tumbling for 80 min and intermittent tumbling (10 min on, 20 min off) for 4 hours. The effectiveness of these tumbling regimes were evaluated at two pump levels (125% and 150% over original raw weight). Also the effect of tumbling for 30 min prior to injection was evaluated.

Conclusions

- Tumbling prior to injection improved ($P<0.05$) injection pick up, retention, yield and tenderness, however, with mini roasts there were no differences between continuous and intermittent tumbling.
- The tumbling regime affected processing characteristics more when roasts were injected 125% above original weight than when roasts were injected 150% above original weight.
- Further research is needed on processing technologies to improve efficiencies in producing these mini roast beef.

Experiment 5.3. Effect of different muscles and method of slicing on the characteristics of stir-fry meat.

Procedures

Six beef cuts, inside round (*semimembranosus* muscle only), outside round (*biceps femoris* muscle), eye of round (*semitendinosus* muscle), knuckle (*vastus lateralis*, *rectus femoris*, *vastus medialis* muscles), chuck clod (trimmed to *infraspinatus* muscle), and chuck tender (*supraspinatus* muscle), from 6 Canada Grade A beef carcasses were tested for stir-fry strips. Different thickness of strips (2, 4, and 6 mm) as well as direction of muscle fibers in the strips (parallel to fibers, perpendicular to fibers and diagonal to fibers) were investigated. Yields and texture of each treatment combination were determined. Texture was determined with a Kramer shear cell attached to a Food Texturometer. A sensory evaluation of stir-fry slices from four meat cuts (knuckle, inside round, eye of round and outside round) was performed.

Results

Meat cut used did not affect the cook yield of stir-fry slices, but shrink was less in slices made from eye of round and chuck tender. Highest shear values were seen for stir-fry strips from the outside round. As expected, thicker slices resulted in higher cook yield, less shrink and higher shear force values. While panelists did not directly compare slice thickness, less connective tissue was perceived for 2 mm thick slices than 4 or 6.

Muscle fiber direction did not significantly affect the cook yield or shrink of stir-fry slices, but had a great impact on the shear force values. This was especially true for the inside round where shear force values were almost doubled *(19.3 N vs 30.3) for meat slices cut parallel to the muscle* fiber direction. Panelists found stir-fry strips from the knuckle to be the most tender and juicy with the least connective tissue and most juicy, while strips from the outside round were the least tender with the most connective tissue. Slices from the eye of round had the lowest flavor desirability and flavor intensity.

Conclusions

- Meat cut used and slice thickness significantly affected the tenderness and apparent shrinkage of stir-fry slices. More work is needed to determine consumer preferences for thickness and size.
- Cook yield for all muscle cuts was similar but very low (50-60%). Alternative processing strategies are needed to offset low cook yields.
- Fiber direction dramatically affected the tenderness of stir-fry slices so it is important to pay close attention to fiber direction when making slices.

Funding

Additional funding for this activity was provided by the Canadian Beef Industry Development Fund (See Appendix 5).

ACTIVITY 6: Functionality Of Selected Cuts For Further Processing (2001-2003)

Background

In earlier work, a series of experiments was completed to determine the effect of muscle cut and different tumbling regimes on the processing characteristics and tenderness of beef roasts. Although the experiments provided much useful data on beef processing, a need for further research to increase yields and improve tenderness of beef products was identified.

In particular, there are few reports on the high level of injection that is currently used in the industry. We observed that beef muscle reacts differently to injection (water addition) and tumbling than does pork and poultry, so some processing techniques previously used for pork and poultry cannot be easily adopted to beef. Because of a higher resistance of beef muscles to liquid addition (mainly because of stronger collagen connections and differences in the muscle structure) it seems that more rigorous physical action is needed to get results similar to other meat species.

It is known that the muscular structure is loosened by means of mechanical processing, which breaks up the cells, making the cellular membranes more permeable and facilitating the distribution and absorption of brine. Water and particle binding which influences the cook yield and tenderness depends primarily on the extraction of myofibrillar proteins from the meat particles. And it is generally accepted that increased tissue disruption and higher ionic strength allows increased protein extractability, resulting in more solubilization of muscle proteins and thus an increase in the cook yield of the products.

Mechanical treatment of meat tissue including tumbling or massaging is a well recognized and accepted technique in the meat industry. Both processes are commonly used to disintegrate external surfaces of meat pieces and to release myofibrillar proteins. Many reports have shown that mechanical tenderisation (e.g. blade tenderisation) significantly improves the tenderness of less tender cuts of meat and is one of the most effective and efficient technologies currently used to ensure tenderness. Although injection technology followed by tumbling is now routinely used by the majority of pork processors to enhance and maintain the tenderness, juiciness and flavour of lean pork cuts it has not been adopted for widespread commercial use by the beef industry. There is little information is available on the effect of extended tumbling regimes on binding and textural characteristics of roast beef. The combination of mechanical tenderisation with the tumbling process may provide a useful means of improving both textural and water binding properties.

Experiment 6.1. The effect of the initial ionic strength and rate of brine addition on the processing characteristics of restructured beef rolls.

The experiment focused on the effect of rate of brine addition on the cook yield and bind strength of restructured beef rolls. Tumbling of meat with all the brine added at the beginning of the process was compared to that with incremental brine addition. Also, the effect of different

initial ionic strength of brine was examined. The effectiveness of these tumbling regimes was evaluated at two pump levels (125 and 150%) over original raw weight.

The objective of this study was to determine the combined effect of time and quantity of water /brine ingredients (salts) addition on quality characteristics of restructured beef rolls processed with 25 or 50% pump level. The rolls were formulated to contain 1.8% sodium chloride and 0.3% sodium tripolyphosphate. Within each pump level, the tumbling treatments were:

1) all the brine added at the beginning of the tumbling;
2) half of the brine added at the beginning and half after 2 h of tumbling;
3) quarter of the brine added at the beginning and the remaining brine after every hour of tumbling;
4) all the salts with half of water added at the beginning and remaining water after 2 h of tumbling;
5) all the salts with a quarter of water added at the beginning and the remaining water after every hour of tumbling.

All treatments were intermittently vacuum tumbled for 4 hours (20 min. on, 10 min. off) at –0.8 atm. pressure and then rolls were water cooked in an air-agitated water bath to a final internal temperature of 72°C. Hydration properties (cook yield, expressible moisture, purge during storage of vacuum packaged slices) and textural characteristics (bind strength, texture profile analysis) of beef rolls were determined.

Results

Brine addition of 50% had detrimental effects on product water binding characteristics. The incremental addition of brine/water during tumbling significantly ($p<0.001$) affected all parameters characterizing water binding properties of the rolls. Regardless of the pump level, cooking loss and expressible moisture was the lowest when half of brine had been added at the beginning and the second part after 2 hours of the tumbling process. When all salts with a quarter of the water were added at the beginning of tumbling, the resulting rolls had the highest losses during the thermal processing and lowest water holding capacity.
High-added water treatments produced rolls that were less hard, chewy and cohesive, and had poorer binding properties than rolls produced with lower water content. The loss in functionality by higher water addition was not overcome by the tumbling treatments. Addition of brine in two parts increased hardness of the cooked meat rolls for both pump levels but was unable to substantially improve bind, cohesiveness or springiness. Late addition of brine/water during tumbling (i.e. during the last hour) adversely affected textural characteristics, which resulted in rolls that were less hard, chewy and elastic, and had poorer binding properties.

Conclusions

- The quantity and timing of brine/water addition is critical in ensuring good water binding and textural characteristics of cooked beef rolls.
- Addition of brine in two parts favourably affected hydration properties, thermal stability and texture, yielding lower cooking loss and purge, and increasing WHC and hardness for rolls with both 25 and 50% added water.

- Late addition of brine/water during tumbling was detrimental and did not permit the incorporation of the water/brine into the muscle cells so that they were retained both in raw and cooked state.

Further research on optimizing processing procedures leading to increase yields and improvements in textural characteristics of beef products is needed. We noted that it is especially difficult to get high cook yields with beef. Furthermore, research is also necessary to develop a better understanding of mechanisms of protein extractability and the function they play both between and within muscle bundles and fibers, and the gel matrix.

Experiment 6.2. Effect of mechanical tenderization and tumbling time on the processing characteristics and tenderness of cooked roast beef.

Treatments to improve tenderness of tough muscles would add value to the whole carcass by enabling processors to market consistently tender products, increasing returns to the processor and satisfying consumer demands. The combination of mechanical tenderisation with the tumbling process may provide a useful means of improving both textural and water binding properties.

Thus the experiment was focused on the combined effect of blade tenderization and extended tumbling time on the processing characteristics and tenderness of cooked beef roasts. No tumbling was compared to short tumbling for 2 h and long term tumbling extended to 16 h. Also, the effect of blade tenderization prior to injection was examined. The effectiveness of these treatments was evaluated at two pump levels (120 and 140%) over original raw weight.

Post-rigor beef inside rounds were used for this study. The *gracilus* and *adductor* muscles were removed and *semimembranosus* muscles were trimmed of all visible fat and connective tissue. Each *semimembranosus* muscle was cut into six small roasts (700 g). The major variables investigated were tenderisation (T and NT), tumbling time (0, 2 and 16 h) and injection (20 and 40%). The roasts designated for tenderisation were blade tenderised, and then all roasts were injected to 120 or 140% over the raw meat weight with brine formulated to give 1.8% sodium chloride and 0.3% sodium tripolyphosphate in the final product. After injection the non tumbled treatments were placed directly into Cry-O-Vac CN 510 cook bags, while the roasts designated for tumbling were vacuum packaged into polyethylene bags and intermittently (20 min on, 10 min off) tumbled (8.5 rpm) for either 2 or 16 h at 4-6°C. The roasts were then water cooked (approx. 150 min) in an air-agitated water bath at 75°C to a final internal temperature of 72°C. The variables measured on each roast included: cook yield (% of green weight), expressible moisture (EM) and purge during storage of vacuum packaged slices. Warner Bratzler shear force (WBS) of 1.27x1.27x2.54cm core samples sheared perpendicular to the fibre direction was determined. Instrumental texture profile analysis (TPA) was performed on six samples per roast using a TMS-90 texture system.

Results

Increasing tumbling time up to 16 h markedly improved cooking yield of the roasts that were injected 120% above original weight, but did not have a significant effect on yield of roasts processed to a 140% pump level. For both injection levels, trends for increased yield were seen when muscles were tenderised. Extending tumbling time to 16 h significantly decreased the percentage of water loss from meat samples after centrifugation, indicating that the longer tumbling improved water retention of beef roasts. Tumbling for 2 h generally was not successful in significantly improving hydration properties of roasts. Regardless of the injection level, tumbling for 16 h resulted in lower storage losses than the samples non tumbled or tumbled only 2 h. The mechanical tenderisation of the beef muscles significantly decreased moisture losses after 3 wk storage. In all treatments more moisture was retained in samples tenderised as compared to those without the mechanical treatment. Extended tumbling (to 16 h) decreased shear force and hardness of beef samples by 50-60%, but was unable to increase springiness or cohesiveness. Blade tenderisation resulted in a decrease in shear force only in roasts produced without tumbling or tumbled 2 h, while its effects was insignificant for roasts tumbled for 16 h.

Conclusions

- Extended tumbling (to 16 h) favourably affected hydration properties and thermal stability, yielding lower cooking loss and purge and higher WHC for beef roasts.
- It also decreased shear force and hardness of beef samples by 50-60%, but was unable to improve springiness or cohesiveness.
- Mechanical tenderisation prior to injection generally was found to be beneficial for textural characteristics, tended to improve cook yield, but did not influence other hydration properties.
- Blade tenderisation may not be necessary to ensure more tender meat when extended tumbling is applied, but would be beneficial when little or no tumbling is applied.

Experiment 6.3. Effects of mechanical treatments and moisture enhancement on the processing characteristics and tenderness of beef from the round.

A number of procedures have been introduced for the enhancement of tenderness and water-binding capacities of under-utilized wholesale cuts from the beef carcass. Blade tenderization and tumbling are well recognized and accepted techniques in the meat industry. Both processes are commonly used to disintegrate external surfaces of meat pieces and to release myofibrillar proteins. Many reports have shown that mechanical tenderisation (e.g. blade tenderisation) significantly improves the tenderness of less tender cuts of meat and is one of the most effective and efficient technologies currently used to ensure tenderness. Recent works investigating the effect of pre-massaging on the processing parameters of cooked roast beef have also demonstrated that pre-massaging can improve yield and tenderness of beef mini roasts.

However, most studies utilize a single physical manipulation method that does not allow the examination of potential synergistic effects of the simultaneous use of two or more methods that may optimize the palatability of under valued cuts that contain higher connective tissue levels.

Whether blade tenderization would have a synergistic effect with pre- and post injection tumbling to improve bind and textural properties in cooked beef rolls is not known. The combination of tenderization with pre- and post-injection tumbling may provide a useful means of improving both textural and water binding properties. In addition, no information is available on the effect of these treatment combinations on binding and textural characteristics of moisture enhanced beef roasts.

Thus, the objective of the study was to determine the combined effect of pre-massaging and blade tenderization on the chemical, binding and textural characteristics of precooked roasts made from round muscles. Also, the effect of moisture enhancement and post-injection tumbling was examined.

Procedures

For each replication, three inside rounds were randomly assigned to one of three treatment groups (no injection, injection, injection and tumbling). Each round was divided into four roasts. Two roasts from each round were blade tenderized, while the other two were kept as non-tenderized control. Then half of the roasts from all groups were subjected to pre-tumbling, while the other half were kept as no pre-tumbled control. Non-injected roasts were placed directly into cook bags and vacuum packaged for cooking. Roast designated for injection were injected using a multi needle injector to 120% over the raw meat weight with brine formulated to give 0.5% salt and 0.3% sodium tripolyphosphate in the final product.

After injection the non tumbled treatments were placed directly into cook bags, vacuum packaged and then refrigerated until heat processed. The roasts designated for tumbling were intermittently (20 min. on, 10 min. off) tumbled for 2 h at 4-6°C. After tumbling, roasts were placed in the cook bags and vacuum packaged for cooking. The roasts were water cooked at 75°C to a final internal temperature of 72°C.

Yields, amounts of free water released during storage of product, expressible moisture and texture and proximate composition of each treatment combination were determined. Texture was determined with WB and Kramer shear cells attached to a Food Texturometer.

Results

The cooking yield of the roasts from the injected (both tumbled and non tumbled) samples was significantly ($P<0.001$) higher compared to those from non-injected roasts. A trend for increased yield was also seen when muscles were tumbled prior to injection ($P=0.087$). Post-injection tumbling had beneficial effects on water holding and moisture retention. Blade tenderization significantly decreased expressible moisture in the injected or injected and tumbled roasts but resulted in a higher percentage of water loss from non injected meat samples after centrifugation, indicating that the tenderization worsened water retention of beef roasts.

Both pre-tumbling and blade tenderization significantly ($P<0.05$) reduced shear force. However, of all the effects studied, moisture enhancement most substantially increased the tenderness of cooked roast beef.There was a significant improvement of Kramer shear values of roasts due to

pre-tumbling observed for either non-injected roasts or those injected but without tumbling. However, no additional reduction in shear force was observed with pre-tumbling when roasts were tumbled after injection.

Conclusions

- Brine injection helped to improve the cook yield and most favorably affected tenderness of SM muscles.

- Post-injection tumbling did not significantly improve yield and textural properties of roasts; however, combined with the tenderization, it had beneficial effects on water holding and moisture retention.

- Pre-tumbling and blade tenderization treatments prior to injection generally were found to be beneficial for textural characteristics; pre-tumbling also tended to improve cook yield, but did not influence expressible moisture.

- Pre-tumbling may not be necessary to ensure more tender roasts when post-injection tumbling is applied, but would be beneficial for non injected roasts or when tumbling is not applied after injection.

- Blade tenderization of tougher cuts such as round muscles can greatly enhance tenderness, but offers no additional advantages with meat tenderized by other methods.

ACTIVITY 7: Processing Characteristics Of Beef And Bison Top Round - Effect Of Moisture Enhancement And Cooking Regimes (2002-2004)

This activity was conducted in cooperation with Drs. Jag Dhanda and Ron Pegg of the Specialty Livestock Value-Added Program.

Background

Most consumers judge quality and overall acceptability of beef products based on tenderness. Cooking has a large effect on meat toughness as water- and fat-binding characteristics, and likewise texture, are closely related to the heating conditions applied. Selecting an appropriate heating rate for cooking a meat product is important in determining the final product quality, and is a particularly important issue in lower value beef cuts because of the high connective tissue content.

There has been some development of new consumer-type cooking protocols for the beef round. On the other hand, there has been little development of cooking protocols for tougher beef cuts to be used by foodservice or by meat processors. Using the optimal heating temperature and humidity and rate of heating is essential in achieving certain quality attributes and economical goals.

Developing new cooking regimes to improve the tenderness of under-utilized muscles would add value to the whole carcass by enabling processors to market consistently tender products, increasing returns to processors and satisfying consumer demands. With this background in mind a study was conducted to determine the combined effect of marination and different cooking regimes on the cooking yield and palatability of beef and bison top round roasts.

Procedures

Eight paired bison and beef top rounds (*semimembranosus*, SM, muscle) were obtained and each SM muscle was divided into four equal portions (800±50g) before processing. Portions from one side were injected to achieve 20% extension by weight and 0.5% NaCl and 0.3% STPP in the finished marinated product, while those from the other side were kept as non-injected control. The marinated product yields based on the green weight were calculated after injection. After marination, roasts were steam-cooked in a smokehouse (single truck Alkar smokehouse, Alkar, Lodi, WI, USA) to a final internal temperature of 71°C using the following four cooking regimes:

- cooking at a constant smokehouse temperature of 75°C (C),
- similar to control cooking except holding the roasts at an internal temperature of 50°C for 45 minutes (H45),
- similar to control cooking except holding the roasts at an internal temperature of 50°C for 90 minutes (H90) and

- finally cooking at 55°C and raising the smokehouse temperature by 5°C every hour till the internal temperature of 71°C was reached (UP).

The effectiveness of these cooking regimes was evaluated on non injected samples and moisture enhanced roasts injected at 120% over original raw weight. Cook yield, pH and proximate analysis of each treatment was determined. Texture was tested using a Warner-Bratzler shear cell attached to a Food Texturometer. Amounts of free water released during storage of product and expressible moisture was also determined.

Results

As expected, bison SM muscle samples were leaner compared to beef samples but there were no significant differences between these two species in terms of protein content. Similar to the findings from the previous studies, injection by marination helped in improving the yield and tenderness of beef and bison SM muscles. The cooking yield for injected samples (78%) was significantly ($P<0.05$) higher compared to non-injected controls (68%). When comparing beef and bison samples, injected bison SM muscle roasts had lower cooking losses than injected beef ones; the cooking yields of control samples from these two species did not differ. Out of the four cooking regimes employed, H45 (holding meat samples at 50°C for 45 minutes) produced a better cooking yield for both injected and non-injected roasts than other regimes tested. Beef SM muscle was more tender than bison SM muscle; however, marination by injection was able to significantly ($P<0.05$) reduce the shear force values (made it more tender) of SM roasts from both species (note: shear force values of 82N in control samples was decreased to 63N in injected ones). Cooking regimes *i.e.*, H45, H90 and UP, produced significantly ($P<0.05$) more tender roasts compared to control steam cooking, these results were more marked for injected steaks, which again emphasize the importance of moisture-enhancement for less-tender cuts. However, there was no significant difference in shear force values between H45, H90 and UP cooking regimes. Owing to a higher cooking yield, injected bison SM muscle roasts had greater expressible moisture and purge (after 3 weeks of storage) compared to those from beef.

Out of the four cooking regimes tested, H45, H90 and UP produced significantly lower shear force values (more tender) than the control, but based on the cooking yield, H45 had an edge over the other regimes employed.

Conclusions

The findings of the present study suggest that bison *semimembranosus* muscle is leaner and comparable in protein, but sometimes less tender than beef. Marination by injection was able to significantly ($P<0.05$) increase the tenderness of *semimembranosus* muscle for both species. The cooking method and internal cooking temperature influenced both the cooking yield and shear force. Owing to a longer time in the temperature range from 50°C to 60°C, the cooking regimes, H45, H90 and Step-up, yielded products with lower shear force values than that of the control. However, the Step-up method resulted in high cooking losses. Based on the cooking yield and time involved, the H45 treatment performed the best.

The results suggest that moisture enhancement of lesser value cuts of beef and bison SM muscles followed by the appropriate cooking regime offers a new means of ensuring consistently tender products.

Note: Costs for the bison component of the research were provided by the Specialty Livestock Value-Added Program (with funding support by the Agri-Food Innovation Fund).

ACTIVITY 8: Effects of Vacuum and Modified Atmosphere Packaging on Colour and Shelf-stability of Bison and Beef Steaks (2002-2004)

This research activity was conducted in collaboration with Drs. Jag Dhanda and Ron Pegg of Specialty Livestock Value-Added Program.

Background

Maintaining quality and appearance is essential during the distribution and merchandising of perishable food products like meat. The only criterion consumers have at the point of purchase when selecting meat cuts is visual appearance. Therefore, the colour of meat is the single most important factor that influences the buying decision of the consumer. Myoglobin, sometimes referred to as dexoymyoblogin (DOMB), is the main pigment of meat and has a purplish red colour. When a freshly cut surface of meat comes in contact with air, DOMB is oxygenated and converted to oxymyoglobin (OMB); this gives beef a bright cherry red appearance and this colour is normally used as an indicator of freshness by the consumer. If only small quantities of oxygen are present, such as in a partial vacuum or a sealed semi-permeable package, DOMB is converted to metmyoglobin (MMB) via oxidation giving the meat a brown appearance. Development of this brown pigment is a serious problem in merchandising meat, because most consumers associate it with a product that has been stored too long. The colour of the meat can be controlled, if the factors influencing it are better understood.

To prevent product shrinkage and to delay the onset of its deterioration, optimum storage temperature and appropriate packaging are necessary for retail display. There are many packaging choices available; however, knowledge of the physical characteristics of the materials and systems in question, along with other factors that influence the keeping quality of meat, is essential when selecting the appropriate packaging. Vacuum (VP) and modified atmosphere packagings (MAP, *i.e.*, with one or more gases) are being used by the industry to design different conditions so as to maximize the shelf-life of meat and to promote desired product attributes. Vacuum packaging is employed to maximize the shelf-life of meat, whereas modified atmosphere packaging (MAP), containing high levels of oxygen, is widely used to attain the bright red colour of meat through oxygenation of DOMB. The most commonly used gases for packaging of meat are carbon dioxide (CO_2), nitrogen (N_2) and oxygen (O_2). The O_2 in the package headspace enhances meat colour and extends the stability of oxymyoglobin, while CO_2 restricts the growth of aerobic spoilage bacteria.

Objectives

The objective of this study was to assess the influence of injection, packaging and storage conditions on the microbial, oxidative and colour stability of beef and bison steaks during retail display.

Procedures

Fresh beef and bison loins (*longissimus lumborum*, LL - 4 each) were procured from local sources. Each LL was divided into two sections. One section was injected with brine containing NaCl and sodium tripolyphosphate (0.5% and 0.3%, respectively in the finished product) to achieve 20% extension by weight, while the other section was kept as a non-injected control. Then, each loin section was divided into as many steaks (1" thick) as possible. These steaks were randomly allocated to storage atmospheres (MAP and VP), storage temperatures (-1 and +4°C) and storage interval subgroups (overnight, 1 and 2 weeks; and 1, 2 and 3 weeks for MAP and VP, respectively). The steaks (48) for VP treatment were individually packaged in ethylene/vinyl acetate copolymer polyvinylidene-chloride (PVDC) laminate bags. After making 2 holes through the over-wrap film for free exchange of gases, the steaks (48) for MAP were transferred to Cryovac B series bags, the headspace was evacuated, filled with a mixture of 70% O_2/30% CO_2 and then sealed. VP and MAP steaks were stored at designated temperatures for set periods.

After removal from the main packaging following the designated storage intervals, pH, 2-thiobarbituric acid reactive substances (TBARS), purge during storage and total aerobic plate counts were determined. Colour (L*, a* and b*) was measured using a HunterLab Miniscan XE colorimeter. Steaks were re-packaged on styrofoam trays over-wrapped with an oxygen permeable film and then placed in a retail display case maintained at 3.0±1°C. Colour (L*, a* and b*) and absorbance was measured using a HunterLab Miniscan XE colorimeter daily for 5 days. Different forms of myoglobin (*i.e.*, OMB, MMB and DOMB) were also calculated.

Results

Owing to a high O_2 concentration and subsequent increased lipid oxidation, MAP beef steaks stored for 1 or 2 weeks exhibited higher thiobarbituric acid reactive substances (TBARS) values compared to VP steaks. In bison meat, lipid oxidation was also significantly influenced by different packaging treatments; however, their effect on TBARS was strongly dependant on injection and temperature of storage, as indicated by the packaging *x* injection and packaging *x* temperature interactions (p=0.000 and p=0.007, respectively). TBARS values for bison steaks stored under MAP for 1 week were higher than those stored under vacuum, while TBARS values for steaks stored under MAP-OV were the lowest (p<0.01). With storage, TBARS also appeared to increase more rapidly in bison meat than beef, especially in non-injected samples stored under MAP.

As expected, microbial loads of steaks that had been injected and the ones stored at +4°C were higher than non-injected steaks and those stored at -1°C, respectively. Modified atmospheres around steaks delayed the time to spoilage, which was evident from the data obtained on microbial load in the present study. Aerobic counts for steaks stored under MAP were better than those stored under VP; nevertheless, counts from both packaging atmospheres were in the acceptable range.

Steaks stored at the lower temperature (-1°C) held better colour than those stored at the higher temperature (+4°C). Non-injected steaks had higher a* values initially, but marination did not significantly (p>0.05) affect colour of beef steaks after 3 weeks of storage. While for bison

steaks, the change in a* values during storage due to brine injection was dependant on storage time and type of packaging. There was a positive influence on the colour of steaks under MAP treatment after overnight and 1 week of storage, whereas the colour of steaks deteriorated (*i.e.*, decreased a* values) significantly ($p<0.05$) after vacuum packaging irrespective of the storage time. These changes in a* values were more pronounced in injected than non-injected bison steaks. The largest increase in a* value of beef and bison steaks was observed during overnight storage under MAP. A slight improvement of the colour was also seen in beef steaks stored under MAP for 1 week. The a* value remained constant in beef steaks held under MAP for 2 weeks and under vacuum for 1 week but decreased significantly after 2 and 3 weeks of storage under VP. Bison steaks held under MAP for 1 week retained a bright red colour only in injected treatments and those stored at the lower temperature. Regardless of storage temperature and injection, bison steaks held under MAP for 2 weeks were totally discoloured, so rendered as unacceptable and were discarded from further assessments.

In the present study, bison meat bloomed quickly with a dark red colour, but it tended to loose its brightness readily during retail display compared to that of beef. HunterLab colour values, particularly a* values, are a good indication of the redness of meat: the higher the a* value, the redder the meat. For beef, the decline in a* values was gradual and significant ($p<0.05$) between day 0 and day 5, whereas for bison the steaks held a bright red colour for only the first 2 days. After which, discolouration of bison steaks became evident; most of the steaks had to be discarded before the completion of the retail display.

As expected, steaks stored at the lower temperature (-1°C) held better colour than those stored at the higher temperature (+4°C). Injection had a beneficial effect on the colour stability of steaks during retail display; however, this positive effect was more pronounced for bison steaks compared to those of beef. Steaks stored overnight under MAP (MAP-OV) prior to retail display maintained the highest a* values (*i.e.*, a brighter red colour) for up to 5 days compared to those stored under vacuum (VP1, VP2 and VP3). Bison steaks stored for 2 weeks under MAP were grossly discoloured by the end of the storage period and were discarded from the retail display study.

Beef steaks maintained significantly ($p<0.05$) higher proportions of OMB compared to bison steaks. Injected steaks and steaks stored at the lower temperature (-1°C) had significantly ($p<0.05$) higher OMB levels compared to non-injected steaks and those stored at the higher temperature (+4°C), respectively. The decrease in proportions of OMB for steaks in the retail display case was dependant upon injection treatment and storage temperature, as injected steaks and those stored at -1°C were generally redder and contained more OMB. This clearly demonstrates the beneficial effects of a lower storage temperature and antioxidative properties of phosphates on muscle colour stability.

Conclusions

Beef LL steaks were able to retain their bright red colour longer and had a slightly higher, although non-significant ($p>0.05$), microbial load compared to bison steaks. The deterioration in colour of bison steaks occurred in advance of significant changes in aerobic plate counts. Bison appears to develop higher TBARS on storage, and this might have an influence on the resulting

more rapid loss of colour with bison. Storage at -1°C provided greater colour stability and longer storage life for both beef and bison meat. MAP is an excellent option for short-term storage due to its positive effects on meat colour, but for longer storage, VP still holds well. Storing meat under vacuum and then placing it under MAP just before retail display might be another option to increase shelf-life.

Marination had a beneficial effect on the colour stability of steaks during retail display, but this positive effect was more pronounced for bison steaks compared to those of beef. The results obtained from the present study support the view that MAP containing a high oxygen concentration is not suitable for long storage; however, such packaging is well suited for display applications when the time between packaging and display is short. High oxygen-containing modified atmospheres tend to stabilize the oxygenated state of DOMB for relatively short periods, whereas VP is a better option when prolonged storage is required.

Note: Costs for the bison component of the research were provided by the Specialty Livestock Value-Added Program (with funding support by the Agri-Food Innovation Fund).

ACTIVITY 9: Postmortem Intervention Strategies to Enhance Tenderness of Underutilized Beef Cuts (2003 to present)

Background

Tenderness has been identified as the single most important palatability factor affecting consumer satisfaction of beef. Since most consumers judge quality and overall acceptability of beef products based on tenderness, the utilization of meat from the beef round and chuck has always been limited by the toughness of the muscles.

Many studies have shown that meat tenderness is mainly associated with the structural integrity of myofibrillar and connective tissue proteins. Connective tissue is dominated by collagen, of which the insoluble portion contributes significantly to meat toughness. Due to its role in locomotion, the *Semitendinosus* contains a uniquely large proportion of elastin, an extremely stable connective tissue. Therefore, commercially applicable methods to degrade the intrinsic collagen and elastin structure to an extent which produces the desired tenderness and texture must be developed on a muscle specific basis to ensure a consistently tender product.

One approach to increasing beef tenderness is to significantly reduce the amount of detectable connective tissues without causing extensive degradation of muscle fibers. This purpose may be achieved by controlled proteolysis of targeted proteins by addition of exogenous enzymes. In the past decade, new generation enzyme technologies have increasingly been applied to all sectors of the agricultural industry (eg. feed, processing aids) but have not yet been widely applied to meat. It is conceivable, however, that with the considerable recent development in the range and availability of economical, highly specific, highly active food grade enzymes, the application of enzyme technology could assist beef processors in their efforts to meet consumer expectations for product quality and consistency.

Furthermore, most studies utilize a single post harvest intervention method that does not allow an examination of potential synergistic effects of the simultaneous use of two or more methods. In addition, with the move to moisture enhancement (and its acceptance by consumers), it now may be more practical to consider the addition of tenderizing agents to marinates to effectively enhance beef tenderness. Optimization of post harvest processing techniques to improve tenderness of underutilized muscles will be essential for achieving quality and economical goals.

Objectives

- to establish guidelines for application of selected proteolytic enzymes to improve palatability and textural characteristics of different beef muscles,
- to examine the combined effects of aging time, mechanical tenderization and controlled proteolysis by exogenous enzymes on tenderness of underutilized beef cuts and,
- to recommend a commercially applicable strategy to ensure a consistently tender product.

Experiments for this activity are underway and will be reported under the new Value-Added Beef Program.

Funding

Partial funding to support this activity has been obtained from the Canadian Beef Cattle Research Council (See Appendix 5).

ACTIVITY 10: Product Development / Extension / Technology Transfer (1996 to present)

Product and Process Development

The Value-Added Beef program has cooperated with / build on the strengths and expertise of the former ADF-funded Value-Added Meats Strategic Research Area (Saskatchewan Food Product Innovation Program, SFPIP) and provided some financial support for their activities, as the meat processing specialist is partially funded from this initiative. SFPIP staff carried out much of the ongoing beef product and process development work. Work often extended beyond the bench-top or pilot scale, with staff providing assistance with scale-up of these new products at the plant level or in cooperation with the Saskatchewan Food Industry Development Centre. Several new and novel beef products have now been commercialized.

In general, product and process development was performed as a response to a market need and demands from the beef industry. There has been a steady demand for the development of value-added products and processing techniques to accommodate the beef sector. Most product development initiatives involved utilizing lesser value cuts of meat and the trimmings with an aim to increase the overall value of the carcass. Lesser value cuts have been used to produce whole muscle products, while trimmings are being utilized in the production of restructured and comminuted meat products. A large focus of development has been in the snack food market; examples include jerky, pepperoni and beer sausage. Other deli products and specialty items such as salamis, smoked sausage and garlic sausage have also seen an increased interest. Determining the shelf life of fresh retail cuts during transportation and ready-to-eat products for the hotel restaurant institution (HRI) trade was also explored.

Over the past eight years several product development projects were undertaken with producers, processors, associations and cooperatives. Several clients came in with only a vague idea of what they wanted. We have been able to help develop their concept and to prepare product prototypes. All these projects were aimed for the domestic market, and where applicable, some for export markets. To name a few, HRI roast beef products developed in cooperation with product development personnel at Food Processing Development Centre, Leduc, Alberta and Food Development Centre, Portage la Prairie, Manitoba, cured beef products for Western Canada Beef Packers, Inc., research and development for FNA Proteins, Calgary, AB as well as several other small and medium-sized projects for various small Saskatchewan processors. Products have also included acidified beef sticks, some prototypes of burgers/patties, marinated cuts (inside and outside rounds) and various sausages. While some were prepared with beef alone, many were beef/pork combinations. Some of the projects were carried out by request of the Saskatchewan Food Industry Development Centre.

Many beef processors were looking for ways to produce acceptable products rather than grind the entire animal into "hamburger." Many processors also encountered problems with products which required ingredient or process changes to meet the ever-changing demands of consumers. Recently Paul Rogers has also developed prototypes of burgers and marinated cuts and sausages for a Saskatchewan beef producer who is developing a market for Natural Angus beef products (no antibiotics).

Extension / Technology Transfer /Education

A number of technical assistance projects in the form of consulting, troubleshooting and extension were undertaken, in addition to the product development initiatives. Some specific events are listed in Appendix 4. Technical questions were addressed on a regular basis by SFPIP and VAB staff. Information was disseminated to the industry *via* seminars, meetings, workshops, newsletters, etc. Several information sheets were developed (Appendix 1). One of the most popular was a publication on meat colour by J. Boles and R. Pegg (Appendix 2), which has been requested by various groups including Saskatchewan Health, Agriculture and Agri-Food Canada, Saskatchewan Agriculture and Food and the Canadian Food Inspection Agency. The various workshops provided are listed in Appendix 4. Note that workshop binders were generally prepared and are available on request.

We also assisted in the expansion and diversification of the Saskatchewan meat processing industry through education and training of Saskatchewan meat processors. Over the eight years, several short courses for individuals with interest in the meat processing sector were provided or coordinated by VAB. We also participated in a number of events coordinated by the Saskatchewan Food Product Innovation Program.

Personnel from the program attended a number of trade shows, conferences, meetings etc. during the past eight years. These included Canadian Cattleman's Association Annual Conventions, Saskatchewan Beef Symposium, Canadian Meat Science Association / Canadian Meat Council's Annual Technology Symposiums, Annual Conventions of Saskatchewan Meat Processors' Association, Western Beef Development Centre Termuende Annual Field Days, Grand Opening of the Saskatchewan Food Industry Development Centre, International Animal Agriculture and Food Science Conference, Reciprocal Meat Conference and International Congress of Meat Science and Technology. Important new contacts were made during these meetings.

Having research and product development infrastructure in place may also help to attract new business to the province. In 1999-2000, we participated in several information sessions with Saskatchewan Economic Development to highlight Saskatchewan's meat research and development capability for a company considering building a new beef patty processing facility in Saskatoon. While our role was very minor, the province was successful in attracting this company to Saskatoon, with the creation of 50 plus jobs and a need for many tonnes of meat (beef in particular).

Since Bovine Spongiform Encephalopathy (BSE) was confirmed in a Canadian cow on May 20, 2003, access to export markets for beef and for movement of beef animals has been severely

curtailed. Saskatchewan beef producers have been much more active in considering alternative ways to market their meat. Many small meat processors have also greatly increased their beef slaughter. Other producers are in the process of developing a marketing plan and the logistics of sales and distribution. Paul Rogers has spent considerable time advising producers on their options.

We have strived to remain up-to-date with the current needs of the beef industry. Paul is a member of the board of directors of the Saskatchewan Meat Processors Association and also sits on the advisory board for SIAST's Retail Meat Cutting Program. Last year, he helped to organize some training sessions on beef slaughter practices (in cooperation with the Saskatchewan Meat Processors Association). In July 2003, he participated on a committee (with the Saskatchewan Meat Processors Association and Saskatchewan Agriculture, Food and Rural Revitalization) to discuss the collection and disposal of Specific Risk Materials (SRM's). Currently, he is participating on a project with Saskatchewan Agriculture, Food and Rural Revitalization to enhance the provincial meat inspection system.

Further, Dr. P. Shand has participated in several events for the Canadian Cattlemen's Association and the Beef Information Centre. She contributed to several of their priority setting events. In 2002, she was invited to present an overview of palatability enhancement through further processing to the Beef Palatability Enhancement Workshop. In 2004, she participated in the Commercial Beef Technical Advisory Group, which was a special task force set up by the Beef Information Centre. The group provided input on research and technology needs for Canadian processors following the BSE crisis.

SUMMARY AND CONCLUSIONS

The Saskatchewan Beef Development Fund (BDF) has provided core funding to the Value-Added Beef program since 1996. The program has worked hard to achieve our objective of establishing an applied research and new product development capability specifically for beef. We have provided a focused research approach to value-added beef development, assisted the industry in understanding the needs of consumers and provided industry support to assist in the development of value-added beef products. The continuity provided by this funding has allowed us to hire skilled personnel to undertake both reactive and proactive research and development activities. We were also able to leverage funds provided by BDF to obtain other grants totaling over $500,000, effectively doubling our beef research and development efforts.

Initiatives undertaken under the VAB program have been focused on various approaches for improving beef quality and consumer satisfaction. They explored the options and potential for adding value to beef products through improving beef quality and tenderness and stimulating beef product development to improve market access and beef's competitive position. Most consumers judge quality and overall acceptability of beef products based on tenderness, which has been identified as the single most important palatability factor affecting consumer satisfaction of beef. Therefore the main emphasis of this program has been to improve the processing characteristics and thus increase utilization of lesser value cuts and thereby increasing the overall value of the carcass.

We have furthered our understanding of how to optimize functionality of the proteins in red meat systems. For example, tumbling can be important to facilitate the restructuring of meat pieces into a value-added final product. However, the quantity and timing of brine/water addition is critical in ensuring good water binding and textural characteristics of cooked beef rolls. We have found that beef muscle has different processing characteristics than pork or poultry, and therefore, there was a need to establish species-specific processes for beef.

Findings from these studies have been communicated to beef producers and processors through presentations and fact sheets/newsletters, and have also been presented at scientific meetings as well as being published in industry magazines and international peer-reviewed journals. Sincere efforts were made to publicize the program and to reach as many producer/processor groups, industry and government personnel as possible.

This program has collaborated with various other departments and groups, including the Department of Animal and Poultry Sciences, Western Beef Development Centre, Department of Agricultural Economics, Saskatchewan Food Industry Development Centre, Saskatchewan Agriculture, Food and Rural Revitalization, Canadian Cattlemen's Association and the Canadian Beef Information Centre (BIC). Indeed, a question posed by the BIC lead to the development of a popular meat colour extension publication from the program.

We are grateful for the collaboration and contribution of the Saskatchewan Food Product Innovation Program (former Value-Added Meats Strategic Research Program) staff (partially funded by this initiative) who carried out much of the ongoing beef product and process

development. Work often extended beyond the bench-top or pilot scale, with staff providing assistance with scale-up of these new products at the plant level or in cooperation with the Saskatchewan Food Industry Development Centre. Several new and novel beef products have now been commercialized.

In January of 2004, the Saskatchewan Beef Development Fund approved funding for an additional five years of partial support for this program. Thus we will continue to have the infrastructure in place to continue our value-added beef research and to assist the industry in any expansion of beef processing activity in the province.

ACKNOWLEDGEMENTS

Financial support for this program by the Saskatchewan Beef Development Fund through the Value-Added Beef Program is gratefully acknowledged. We would like to thank the Dean, College of Agriculture, and the Head, Department of Applied Microbiology and Food Science, for providing infrastructure and administrative support for this program. Dr. Jane Ann Boles, now at Montana State University, is also acknowledged for her major contribution to this project.

Thanks are expressed to the personnel from the Saskatchewan Food Product Innovation Program and later the Meat Group at the University of Saskatchewan for their technical assistance: D.D. Pobereznek, W.P. Rogers, and R.T. Sefton for meat processing and product development, H.D. Silcox for chemical analysis and M. Dworaczek for microbiological analysis and G. Soehn for administrative assistance.

We would also like to thank D.J. Prefontaine and S.Y.C. Lui from the Saskatchewan Food Industry Development Centre for their continued support during various activities of the program.

The authors also acknowledge the support of K. Erin (Food Processing Development Centre, Leduc, AB) and J. Aalhus and J. Janz (Agriculture and Agri-Food Canada Research Centre, Lacombe, AB). Contributions of J. Taylor and I. McNinch (Department of Agricultural Economics) are also acknowledged. Thanks are also due to H. Javid and other personnel from the Saskatchewan Agriculture, Food and Rural Revitalization for their input to the program.

APPENDIX 1: Publications Resulting

Peer-Reviewed Journal Articles

Published

Boles, J.A., Shand, P.J. 1998. Effect of comminution method and raw binder system in restructed beef. Meat Science, 49 (3), 297-307.

Boles, J.A., Shand, P.J. 1999. Effects of raw binder system, meat cut and prior freezing on restructured beef. Meat Science, 53 (4), 233-239.

Boles, J.A., Rathgeber, B.M., Shand, P.J. 2000. Recovery of proteins from beef bones and the functionality of these proteins in sausage batters. Meat Science, 55 (2), 223-231.

Boles, J.A., Shand, P.J. 2001. Meat cut and injection level affects the tenderness and cook yield of processed roast beef. Meat Science, 59 (3), 259-265.

Boles, J.A., Shand, P.J. 2002. Tumbling regime effects on the processing characteristics and tenderness of cooked roast beef. Journal of Muscle Foods, 13, 25-35.

Pietrasik, Z., Shand, P.J. 2003. The effect of quantity and timing of brine addition on water binding and textural characteristics of cooked beef rolls, Meat Science, 65, 2, 771-778.

Pietrasik, Z., Shand, P.J. 2004. Effect of blade tenderization and tumbling time on the processing characteristics and tenderness of injected cooked roast beef, Meat Science, 66, 4, 871-879.

Pietrasik, Z., Dhanda, J.S., Pegg, R.B. Shand, P.J. 2004. The effect of marination and cooking regimes on water binding properties and tenderness of beef and bison top round roasts. Accepted by Journal of Food Science.

Manuscripts in preparation

Boles, J.A., Shand, P.J. Effect of muscle properties on stir-fry meats.

Dhanda, J.S., Pietrasik, Z., Pegg, R.B., Shand, P.J. Influence of injection, packaging and storage conditions on the colour stability of beef and bison steaks in the retail display case.

Janz, J.A.M., Pietrasik, Z., Aalhus, J.L. and Shand, P.J. The effects of enzyme and phosphsate injections on the quality of beef semitendinosus.

Pietrasik, Z., Shand, P.J. Effects of mechanical treatments and moisture enhancement on the processing characteristics and tenderness of beef from the round.

Non-refereed Research Publications

Pietrasik, Z., Shand, P.J. (2003) Manipulating Brine Addition to Improve Water Binding and Textural Characteristics of Cooked Restructured Beef Rolls. Feedinfo News Service Scientific Reviews. November 2003. Available from URL: http://www.feedinfo.com.

Abstracts and Conference Proceedings

Boles, J.A. and Shand, P.J. 1997. Evaluation of comminution method and raw binder system on restructured beef. 43rd Proc. International Congress of Meat Science and Technology p. 376-377.

Boles, J.A. and Shand, P.J. 1998. Extraction of proteins from bone and the functionality of these proteins in sausage batters. 51st Reciprocal Meat Conference. University of Connecticut.

Boles, J.A., Shand, P.J. 2000. Meat cut and level of injection affect the processing characteristics and tenderness of cooked roast beef. 46th International Congress of Meat Science and Technology, Buenos Aires, Argentina, Aug. 27-Sept. 1.

Boles, J.A., Shand, P.J. 2000. Influence of muscle cut, slice thickness and muscle fiber direction on propoerties of beef stir-fry slices. 46th International Congress of Meat Science and Technology, Buenos Aires, Argentina, Aug. 27-Sept. 1.

Pietrasik, Z., Shand, P.J. 2002. Properties of restructured beef rolls as affected by incremental brine/water addition. 55th Reciprocal Meat Conference, East Lansing, Michigan, July 28-31. 2002.

Pietrasik, Z., Shand, P.J. 2002. Effect of mechanical tenderization and tumbling time on the processing characteristics and tenderness of cooked roast beef. Proc. 48th International Congress of Meat Science and Technology, Rome, Italy.

Pietrasik, Z., Dhanda, J.S., Shand, P.J., Pegg, R.B. 2003. Influence of marination and cooking regime on the tenderness of beef and bison top round roasts, 56th Reciprocal Meat Conference, Columbia, Missouri, June 28-31, 2003.

Janz, J.A.M., Pietrasik,, Z. 2004 Injected enzyme effectiveness is dependent upon cooking method, Canadian Meat Science Association Technical Symposium, Calgary, February 4, 2004.

Pietrasik, Z., Dhanda, J.S., Shand, P.J., Pegg, R.B. 2004. Effect of moisture enhancement and cooking regime on the tenderness of beef and bison top round roasts, Canadian Meat Science Association Technical Symposium, Calgary, February 4, 2004.

Pietrasik, Z., Dhanda, J.S., Pegg, R.B., Shand, P.J. 2004. Influence of injection, packaging and storage conditions on the microbial and colour stability of beef and bison steaks. 50th International Congress of Meat Science and Technology, Helsinki, Finland.

Dhanda, J.S., Pietrasik, Z., Shand, P.J, Pegg, R.B. 2004. Performance during retail display of beef and bison steaks after storage under vacuum and modified atmosphere packaging. 50th International Congress of Meat Science and Technology, Helsinki, Finland.

Pietrasik, Z., Shand, P.J. 2004. Effects of mechanical treatments and moisture enhancement on the processing characteristics and tenderness of beef semimembranosus roasts. Reciprocal Meat Conference, Lexington, Kentucky.

Fact-sheets and Information Sheets

Developed fact sheet on restructured meat products.

Developed fact sheet on meat colour. (provided in Appendix 2).

Developed fact sheet entitled "Beef carcass more than just steaks".

New value cuts increase opportunities for the beef industry. Meat Matters - Saskatchewan Food Product Innovation Program's Newsletter, February 2003.

Adding value to meat products- marination. Meat Matters, Saskatchewan Food Product Innovation Program, Research and Development for the Meat Industry, March, 2003

Increasing the palatability of less tender cuts: Cooking strategies. Meat Matters - Saskatchewan Food Product Innovation Program's Newsletter, December, 2003

Contributed to several Western Beef Development Centre newsletters.

APPENDIX 2: Example of Extension Publication: Meat Colour

APPENDIX 3: Lectures, Presentations and Workshops

Invited Lectures and Conference Presentations

Boles, J.A. 1996. Lecture on Manufacture of Meat Products to the YMCA Youth Program, April 18. University of Saskatchewan

Boles, J.A. 1997. Lecture on the Manufacture of Meat Products for the YMCA youth training seminars. University of Saskatchewan

Boles, J.A. 1998. Presented talk on emulsion products for the Saskatchewan Meat Processors Convention. February 28.

Boles, J.A. 1998. Presented talk and prepared value-added beef products for the Saskatchewan Meat Processors Convention. March 1.

Boles, J.A. 1998. Presented talk entitled "Beef - The Next Generation" at the Saskatchewan Beef Symposium. 150 participants November

Boles, J.A. 1998. Presented talk entitled "Beef - The Next Generation" for the Tisdale Wheat Pool Seminar. 15 participants February.

Shand, P.J. 1999. Making The Most Of The Beef Carcass – The Search For Beef Wings. Saskatchewan Beef Symposium. Nov. 16-17.

Shand, P.J., Pietrasik, Z. 2002. Moisture Enhancement and Mechanical Tenderization. The Beef Palatability Enhancement Workshop Proceedings, Calgary Alberta, November 13-14.

Shand, P.J. 2002. Meat Processing Industry Trends and Opportunities. Saskatchewan Agriculture and Food Rural Economic Opportunities Conference, March 20.

Shand, P.J. 2003. The New Meat Case: Processing Interventions to Enhance Palatability of "Fresh" Meats, Canadian Society of Animal Science Conference, Saskatoon, June

Short-Courses and Workshops

Boles, J.A. 1997. Presented a one-day short course on sausage manufacture and use of cold-set binders for personnel of the Food Development Centre, Portage la Prairie, MB May 22.

Boles, J.A. 1997. Invited speaker at the Meat Product training course at the Meat Industry Research Institute of New Zealand. Topics covered included ham and bacon, sausages, fresh meat and cold-set restructured products. July 22 - 25.

Sonstelie, T. 1997. A 2-day beef processing training workshop was developed and conducted for a visiting meat processor from the Czech Republic. The meat processor buys product from Canada and wanted to learn more about Canadian processing methods.

Boles, J.A., Shand, P.J. and others. 1998. In March 1998, a Restructured Meats Training Workshop was conducted by VAB personnel. Topics covered during workshop included: different binders available, how size reduction affects texture and bind, how different meat sources affect texture, hands on use of different binder systems, product handling do's and don'ts. University of Saskatchewan.

Boles, J.A., Shand, P.J. and others. 1999. In September 1999, a workshop entitled "Processing Of Whole Muscle Products" was presented by the VAB program in cooperation with the Saskatchewan Food Product Innovation Program.
Topics included: meat as a raw ingredient, non-meat ingredients and the control of ingredient levels in the final product, development of brine formulations for different injection levels, injection and tumbling practices, production practices for marinated products, production practices for roast beef, trouble-shooting, critical control points. University of Saskatchewan.

Shand, P.J., Pietrasik, Z. and Rogers, P. 2001. On May 15, 2001, the program delivered a seminar entitled "Value-Added Beef Program Update" in Saskatoon. Ms. Kathy Keeler, Executive Director, Beef Information Centre provided a feature presentation on the Beef Product Development Initiative. P. J. Shand and Z. Pietrasik then provided an update on past and current research of the VAB program. P. Rogers discussed current issues and challenges of beef product development. Several value-added beef products were featured at coffee breaks and lunch. The afternoon was devoted to tours of the College of Agriculture meat processing and product development facilities and the Saskatchewan Food Industry Development Centre.

Rogers, P., Shand, P.J. and others. 2002, 2003, 2004. In the past three years, five very successful short courses entitled "Sausage and Processed Meats" were provided by The Saskatchewan Food Product Innovation Program, with funding support from CARDS.
Participants from different businesses/operations with interest in the meat processing sector from across Canada participated in the courses. Topics presented during courses ranged from basic sausage making procedures, the role and function of meat and non-meat ingredients, curing technology, along with more advanced topics including marinating techniques, smokehouse optimization and coating systems. Included some discussions on beef.

Rogers, P. 2003. Presented two lectures on meat processing at a Sausage and Processed Meat Short-Course, Alberta Food Processing Development Centre, Leduc, Alberta

APPENDIX 4: Industry Outreach / Consulting (selected items)

Dr P.J. Shand participated in a Beef Product Development Technical Group organized and sponsored by the Beef Information Centre, December 7-8, 1995 and May 31, 1996.

Dr. J.A. Boles participated in a panel discussion on Quality Assurance at the Saskatchewan Cattle Feeders General Meeting, February 7, 1997.

VAB staff judged at the Saskatchewan Meat Processors processed meats competition, 1997 to present.

Dr. J.A. Boles participated in a booth with the Western Beef Development Centre at the Canadian Cattleman's Association annual meeting (August 7 - 8, 1997). Jerky was manufactured and given out as samples.

Dr. J.A. Boles conducted tours of the meat processing facilities of the University of Saskatchewan and H. Silcox and T. Goldade demonstrated some research techniques that are used in meat research for interested participants at the Canadian Cattleman's Association annual meeting (August 6, 1997).

Various tours of the meat processing facilities were conducted eg. tours for a Australian Farmers group (August 4, 1998) and the Manitoba Women's Entrepreneurs Group (September 16, 1998)

J. A. Boles was a member of a Health Canada Committee developing policy and microbial standards for foods of raw animal origin. December 1998 to 2000.

Information was supplied to Beef Information Centre personnel on fresh meat colour. (Feb 1999).

A seminar entitled "Serving the consumer market – An evaluation of value-added processed beef products" for Saskatchewan processors was held on April 30, 1999.

On June 22, 2000, the program (in cooperation with the Saskatchewan Food Innovation Program) had a display at the Western Beef Development Centre 2nd Annual Termuende Research Farm Field Day. Samples of beef jerky were also provided.

Dr. Phyllis Shand was an invited participant to the Canadian Cattleman's Association Workshop on *E.coli 0157:H7* held on November 27 and 28, 2000 in Calgary Alberta.

Program staff participated in a 2 day meeting of the Western Canada Research Group on Meat Safety and Preservation on April 19-20, 2001. P. Shand gave a presentation outlining meat research activities at the University of Saskatchewan and described the activities of the Value Added Beef Program.

On June 27, 2001, VAB staff participated in the Western Beef Development Centre Termuende Field day. Beef jerky samples were available for tasting.

On May 29, 2002 during the Steering Committee Meeting of the Strategic Research Program – Area VII Value Added Processing – Meat, Z. Pietrasik provided an update on past and current research of the VAB program.

On June 21, 2002, Dr P.J. Shand participated in the seminar organized by Saskatchewan Agriculture and Rural Revitalization, in partnership with the University of Saskatchewan during which the findings of a study entitled "Market Intelligence – Organic Beef" were presented.

On September 19, 2002, P.J. Shand attended National Beef Industry Development Fund Priority Setting Workshop, Calgary, AB.

On November 19-20, 2002, Z. Pietrasik and P. Rogers visited the Meat Research Centre of Agriculture and Agri-Food Canada in Lacombe, AB and Food Processing Development Centre in Leduc, AB to discuss current issues and challenges of beef product development and to explore the possibilities of cooperation on beef research projects.

On March 1, 2002, Beef Information Centre representatives from across Canada visited our pilot plant facilities. During round table discussion, current issues and challenges of beef product development were highlighted. Dr P.J. Shand then described meat research activities at the University of Saskatchewan and made a presentation entitled "Meat Research at the U of S" and Z. Pietrasik outlined the beef research projects of the Value Added Beef Program. The afternoon was devoted to tours of the College of Agriculture meat processing and product development facilities and the Saskatchewan Food Industry Development Centre.

In July, 2003, P. Rogers participated on a committee (with the Saskatchewan Meat Processors Association and Saskatchewan Agriculture, Food and Rural Revitalization) to discuss the collection and disposal of Specific Risk Materials (SRM's).

In February, 2004, P. Rogers gave a presentation to the Saskatchewan Stock Growers Association, Minton, SK.

APPENDIX 5: Additional Funding Obtained

The VAB program has been able to leverage funds provided to this project from BDF and maintain close research ties with other departments. Since 1996, there was over $450,000 in additional funding to the program from five collaborative beef projects. With the current research grant to the program from the Canadian Beef Cattle Research Council (#6 below), we will continue to explore technologies that will allow underutilized beef cuts to be processed into consumer-oriented value-added products

1. Utilization of Beef Bones
   J.A. Boles and P.J. Shand 1996-1998
   Agriculture Development Fund $26,750

2. Processing Procedures for Restructured Meats
   J.A. Boles and P.J. Shand 1996-1998
   Saskatchewan Agriculture Development Fund $30,000

3. Demand for Value Added Beef Products
   (cooperative project with Agricultural Economics)
   J.S. Taylor and J.A. Boles 1997-1999
   Saskatchewan Agriculture Development Fund and Saskatchewan Beef Development Fund $150,000

4. Functionality Of Selected Beef Cuts For Further Processing
   J.A. Boles and P.J. Shand 1997-2000
   Canadian Beef Industry Development Fund $149,177

5. Effect of Supplemental Calcium and Vitamin D in Feedlot Diets on Beef Tenderness
   (co-operative project with the Department of Animal and Poultry Science)
   J.M. McKinnon and J.A. Boles 1998-2000
   Agriculture Development Fund $103,600

6. Postmortem Intervention Strategies to Enhance Tenderness of Underutilized Beef Cuts
   P.J. Shand, M.A. Price and J. Aalhus 2003-2006
   Canadian Beef Cattle Research Council $97,513.50

APPENDIX 6: Personnel Associated With The Value-Added Beef Program.

Personnel funded by VAB project:

Dr. Jane Ann Boles	100% of time	3.5 person years
Dr. Zeb Pietrasik	100% of time	3 person years
Paul Rogers	10% of time	0.3 person years
Tracey Goldade	20% of time	0.6 person years
Trevor Sonstelie	40% of time	1 person year

Staff hired on related grants:

Lona Takatch	100% of time	1.5 person years
Cheryl Thompson	60% of time	1.5 person years

Other Personnel Contributing to the Program from the University of Saskatchewan:

Department of Applied Microbiology and Food Science
- Dr. P.J. Shand (Principal Investigator)
- Dr. A.R. McCurdy
- Dan Prefontaine
- Gerald Henriksen
- Derrick Pobereznek
- Heather Silcox
- Ryan Sefton
- Gail Soehn
- Dr. R. Pegg
- Dr. J. Dhanda
- Michal Dworaczek
- Ursla Fernando

Department of Agricultural Economics
- Mr. I. McNinch
- Dr. J. Taylor
- Ms. C. Springford

Department of Animal and Poultry Sciences
- Dr. F. Buchanan
- Dr. J. McKinnon
- Dr. S. Schmutz

Other Personnel Contributing to the Program from Other Agencies:

Saskatchewan Food Industry Development Centre
- D. Prefontaine
- S. Lui

Agriculture and Agri-Food Canada
- Dr. J. Aalhus

Food Processing Development Centre, Leduc
- K. Erin
- B. Gibson

University of Alberta
- Ms. J. Janz
- Dr. L. McMullen
- Dr. M. Price

Montana State University
- Dr. J. Boles